The Center
FOR COMPREHENSIVE SCHOOL REFORM AND IMPROVEMENT

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NEWSLETTER

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GETTING TO "GOT IT!"

Helping Mathematics Students Reach Deep Understanding

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It comes as no surprise that what teachers do in the classroom impacts students' learning of mathematics. During a single class period, a teacher makes countless decisions about how to present material, structure tasks, and guide student learning. Some decisions seem large, such as how to grade students and how to introduce new concepts. Other teacher decisions may seem less significant, such as the choice of how to position students' seats, which problems to assign for homework, or whether or not to ask students to raise hands before answering questions. In essence, effective teaching is effective decision-making, as the collection of big and small decisions made by mathematics teachers makes a tremendous difference in students' learning. How do teachers decide what to do when they teach? These decisions may be based on their training or professional development experiences, what they experienced as students, or what they have learned from colleagues. A recent practice guide titled Organizing Instruction and Study to Improve Student Learning *aims to supplement and inform teachers' instincts and experiences by identifying research-based instructional strategies that teachers of all content areas can use to improve student learning.*

The practice guide identifies the following seven recommendations (Pashler et al., 2007, p. 2):

1. *"Space learning over time.* Arrange to review key elements of course content after a delay of several weeks to several months after initial presentation."

2. *"Interleave worked example solutions with problem-solving exercises.* Have students alternate reading already worked solutions and trying to solve problems on their own."

3. *"Combine graphics with verbal descriptions.* Combine graphical presentations (e.g., graphs, figures) that illustrate key processes and procedures with verbal descriptions."

4. *"Connect and integrate abstract and concrete representations of concepts.* Connect and integrate abstract representations of a concept with concrete representations of the same concept."

5. *"Use quizzing to promote learning.* Use quizzing with active retrieval of information at all phases of the learning process to exploit the ability of retrieval directly to facilitate long-lasting memory traces."

   5a. "Use pre-questions to introduce a new topic."

   5b. "Use quizzes to re-expose students to key content."

6. *"Help students allocate study time efficiently.* Assist students in identifying what material they know well, and what needs further study, by teaching children how to judge what they have learned."

   6a. "Teach students how to use delayed judgments of learning to identify content that needs further study."

   6b. "Use tests and quizzes to identify content that needs to be learned."

7. *"Ask deep explanatory questions.* Use instructional prompts that encourage students to pose and answer deep-level questions on course material. These questions enable students to respond with explanations and support … deep understanding of taught material."

All of the recommendations from the practice guide suggest rigorously researched instructional strategies that have been shown to positively impact student learning. Because of space limitations, this newsletter will focus on only the last two of these recommendations.

Recommendation 6 targets what researchers call *metacognition*—literally thinking about thinking. As teachers are well aware, many students find it difficult to assess accurately what they do and do not understand. As the time for a unit test approaches, teachers often hear that students do not know how to study for mathematics tests and do not know which problems they can and cannot solve. Students' difficulties in accurately assessing what they do and do not know can make it extremely challenging for them to prepare properly for assessments.

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Pashler et al. (2007) suggest the use of what researchers call the *cue-only judgment of learning* approach, which can be particularly effective as an in-class or at-home review activity (p. 23). At the end of a chapter or lesson, the teacher asks students to complete a series of problems and to rate each problem according to how well they understood it. After completing all of the problems, the students are asked to return to the problems they rated with low scores (the poorly understood problems). This activity can be repeated until the number of problems with low ratings is reduced for each student.

Teachers who find this strategy to be obvious or intuitive would be surprised to learn that many students do not know this strategy for monitoring their own understanding and find it, at least initially, challenging to implement. But over time, and with continued practice, this approach and others like it have been shown to be quite effective at building students' metacognitive abilities, enabling them to accurately gauge what they do and do not understand.

Once students begin to gauge better what they know and do not know, they may be ready to reap the benefits from the practice guide's seventh and final recommendation—that teachers "encourage students to pose and answer 'deep-level' questions" (Pashler et al., 2007, p. 2). Deep-level questions—such as those that begin "why"—can prompt students to probe and explain their thinking. In fact, the ability to answer deep-level questions is usually what we mean when we say that a student understands.

In mathematics class, a commonly used type of deep-level question asks students to justify how they solved a problem. Justifying a solution means looking beyond the right answer and explaining and defending how the approach was chosen, why it is a good approach, and how one knows that the answer is in fact correct. An incorrect answer has equal potential to be a learning opportunity for students when paired with deep-level questions; a student can be asked to explain how he or she knows that the answer is incorrect, to compare and contrast different approaches that may have led to different answers, and to identify and correct the error.

These two strategies—encouraging students to become more metacognitive and asking deep-level questions—go hand in hand. The ultimate goal is for students to learn to ask themselves and their peers deep-level questions in order to assess and build their own deep understanding of mathematics. These strategies and the five practice guide recommendations not discussed here provide concrete and useful suggestions to help mathematics teachers foster "not only initial learning and understanding, but—equally importantly—the long-term retention of information and skills" (Pashler et al., 2007, p. 33).

Reference

Pashler, H., Bain, P. M., Bottge, B. A., Graesser, A., Koedinger, K., McDaniel, M., et al. (2007). *Organizing instruction and study to improve student learning. IES practice guide* (NCER 2007-2004). Washington, DC: National Center for Education Research. Retrieved February 28, 2008, from http://ies.ed.gov/ncee/wwc/pdf/20072004.pdf

After reading this newsletter, please visit The Center's website (**www.centerforcsri.org**) to watch the archived version of The Center's webcast, "Making Algebra Work: Instructional Strategies That Deepen Student Understanding." The website also offers access to some of Dr. Star's research and video from the Montgomery County Public Schools' program, "The Math Dude." Additional scenes are also available from the classrooms featured in the webcast.

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